

WHAT IS CLAIMED IS:

- 1 1. A method of processing an input image, comprising:
2 sub-sampling the input image to generate a thumbnail image; and
3 detecting redeye pixel areas in the thumbnail image.
- 1 2. The method of claim 1, wherein detecting redeye pixel areas
2 comprises computing measures of pixel redness in the thumbnail image, and
3 identifying a preliminary set of candidate redeye pixel areas based on the
4 computed pixel redness measures.
- 1 3. The method of claim 2, wherein pixel redness measures are
2 computed based on a ratio of a measure of a red component of pixel energy to a
3 measure of total pixel energy.
- 1 4. The method of claim 2, wherein identifying the preliminary set of
2 candidate redeye pixel areas comprises applying a two-dimensional redness filter
3 to the computed pixel redness measures, wherein the redness filter is operable to
4 compute a redness score based on a central kernel pixel area and a pixel area
5 surrounding the kernel pixel area.
- 1 5. The method of claim 4, further comprising applying a prescribed
2 threshold to the computed redness scores to identify candidate redeye pixels.
- 1 6. The method of claim 5, wherein detecting redeye pixel areas further
2 comprises segmenting redeye pixels by scanning a redness map of the redness
3 measures in stripes of one or more pixel lines and tracking objects containing
4 candidate redeye pixels connected across stripes.
- 1 7. The method of claim 4, wherein detecting redeye pixel areas further
2 comprises filtering from the preliminary set each candidate redeye pixel area
3 having a computed redness contrast relative to at least one respective neighboring
4 pixel area less than a prescribed redness contrast threshold.
- 1 8. The method of claim 7, wherein each candidate redeye pixel area
2 having a computed redness contrast relative to each of a set of corresponding

3 surrounding pixel areas less than the prescribed redness contrast threshold is
4 filtered from the preliminary set.

1 9. The method of claim 2, wherein identifying the preliminary set of
2 candidate redeye pixel areas comprises enlarging a given candidate redeye pixel
3 area having a dimension below a threshold size to generate an enlarged pixel
4 area.

1 10. The method of claim 9, wherein identifying the preliminary set of
2 candidate redeye pixel areas comprises comparing the enlarged pixel area to
3 multiple pixel areas surrounding the enlarged pixel area, and selecting a pixel area
4 to replace the given candidate redeye pixel area from among the enlarged pixel
5 area and the surrounding pixel areas based on measures of redness computed for
6 each of the enlarged pixel area and the surrounding pixel areas.

1 11. The method of claim 2, wherein detecting redeye pixel areas further
2 comprises filtering from the preliminary set each candidate redeye pixel area
3 located in an area of the digital image having a computed grayscale contrast
4 relative to at least one respective neighboring pixel area less than a prescribed
5 grayscale contrast threshold.

1 12. The method of claim 11, further comprising:
2 computing measures of pixel grayscale in the digital image;
3 computing, for a given candidate redeye pixel area, a candidate iris area
4 centered at the given candidate redeye pixel area and having a size maximizing
5 grayscale contrast between the candidate iris area and areas surrounding the
6 candidate iris area;
7 computing a measure of grayscale contrast between the candidate iris area
8 and at least a portion of the areas surrounding the candidate iris area;
9 and applying a threshold to the computed grayscale contrast measure to
10 filter candidate redeye pixel areas from the preliminary set.

1 13. The method of claim 2, further comprising:
2 identifying a pixel boundary of a pixel region surrounding a given
3 candidate redeye pixel area;

4 classifying pixels within the pixel boundary as red pixels and non-red
5 pixels by applying a threshold to the computed pixel redness measures; and
6 filtering the given candidate redeye pixel area from the preliminary set
7 when a set of contiguous red pixels extends from the given candidate redeye pixel
8 area to the pixel boundary.

1 14. The method of claim 13, further comprising identifying the set of
2 contiguous pixels by scanning a redness map of the redness measures in stripes of
3 one or more pixel lines and tracking objects containing red pixels connected
4 across stripes.

1 15. The method of claim 2, further comprising filtering candidate redeye
2 pixel areas from the preliminary set based on proportions of detected skin tone
3 pixels in regions respectively surrounding the candidate redeye pixels areas.

1 16. The method of claim 2, further comprising pairing candidate redeye
2 pixel areas in the preliminary set, and filtering unpaired candidate redeye pixels
3 areas from the preliminary set.

1 17. The method of claim 16, wherein pairing candidate redeye pixel
2 areas comprises comparing a candidate texture pattern computed for a candidate
3 pair of candidate redeye pixel areas in the preliminary set with a reference texture
4 pattern.

1 18. The method of claim 17, wherein comparing the candidate texture
2 pattern with the reference texture pattern comprises generating a feature vector
3 representative of the candidate texture pattern and comparing the generated
4 feature vector with a statistical model of the reference texture pattern.

1 19. The method of claim 18, wherein generating the feature vector
2 representative of the candidate texture pattern comprises mapping a candidate
3 redeye pair region encompassing the candidate redeye pair to a standardized
4 candidate redeye pair template.

1 20. The method of claim 19, wherein mapping the candidate redeye pair
2 region comprises cropping a pixel region from a grayscale map of the thumbnail
3 image, rotating the cropped pixel region, and scaling the rotated pixel region.

1 21. The method of claim 20, wherein mapping the candidate redeye pair
2 region comprises normalizing and equalizing the scaled pixel region.

1 22. The method of claim 19, wherein generating the feature vector
2 representative of the candidate texture pattern comprises converting the mapped
3 candidate redeye pair region to the feature vector.

1 23. The method of claim 1, further comprising detecting redeye pixel
2 areas in the input image, and generating a set of detected redeye pixel areas by
3 merging redeye pixel areas detected in the input image with redeye pixel areas
4 detected in the thumbnail image.

1 24. The method of claim 1, further comprising correcting redeye in the
2 input image based on redeye pixel areas detected in the thumbnail image.

3 25. The method of claim 24, wherein correcting redeye comprises
4 mapping the detected redeye pixel areas to the input image.

1 26. The method of claim 25, wherein correcting redeye comprises
2 enlarging redeye pixel areas mapped to the input image.

1 27. The method of claim 26, wherein the mapped redeye pixel areas are
2 enlarged by amounts decreasing inversely with respect to original sizes of the
3 mapped redeye pixel areas.

1 28. The method of claim 26, further comprising cropping corners from
2 each of the enlarged redeye pixel areas.

1 29. The method of claim 25, further comprising classifying pixels as
2 redeye pixels for correction before mapping detected redeye pixel areas to the
3 input image.

1 30. The method of claim 24, wherein correcting redeye comprises
2 identifying discrete redeye pixel areas separated from eyelid regions.

1 31. The method of claim 30, wherein identifying discrete redeye pixel
2 areas comprises comparing at least one redeye pixel area size dimension to a
3 threshold.

1 32. The method of claim 31, wherein a discrete redeye pixel area is
2 identified based at least in part on a prescribed fraction of a respective grayscale
3 iris area centered at a corresponding pixel area and having a size maximizing
4 grayscale contrast between the grayscale iris area and areas surrounding the
5 grayscale iris area.

1 33. The method of claim 30, wherein correcting redeye comprises
2 classifying pixels in each non-discrete redeye pixel area based on skin tone
3 coloration.

1 34. The method of claim 24, wherein correcting redeye comprises
2 classifying pixels in each redeye pixel area based on a redness threshold.

1 35. The method of claim 24, wherein pixels are classified on a pixel-by-
2 pixel basis.

1 36. The method of claim 24, wherein each pixel is classified with
2 reference to an adjacent, previously-classified pixel.

1 37. The method of claim 24, wherein correcting redeye comprises
2 classifying pixels between concentric inner and outer bounding regions based on
3 a grayscale threshold.

1 38. The method of claim 37, further comprising correcting original color
2 values of pixels in a redeye pixel correction region encompassing pixels classified
3 as redeye pixels.

1 39. The method of claim 38, wherein original color values of pixels in
2 the redeye pixel correction region are corrected by desaturating original color
3 values.

1 40. The method of claim 39, wherein original color values are
2 desaturated by respective amounts varying with pixel location in the final pixel
3 mask.

1 41. The method of claim 39, wherein original color values of pixels in
2 the redeye pixel correction region are corrected by darkening the original color
3 values.

1 42. The method of claim 38, further comprising correcting original color
2 values of pixels in a smoothing region surrounding the redeye pixel correction
3 region.

1 43. The method of claim 42, wherein original color values of pixels in
2 the smoothing region are corrected by an amount decreasing with distance from
3 the given redeye pixel correction region.

1 44. The method of claim 43, wherein original color values of pixels in
2 the redeye pixel correction region are corrected without reference to position
3 within the redeye pixel correction region.

1 45. The method of claim 37, further comprising computing a size of the
2 inner bounding region between a given redeye pixel area size and a
3 corresponding grayscale iris area size, and computing a size of the outer bounding
4 region larger than the computed size of the inner bounding region by a
5 predetermined relative amount.

1 46. The method of claim 24, wherein original color values of pixels are
2 corrected based on integer arithmetic computations.

1 47. The method of claim 1, further comprising correcting redeye in the
2 thumbnail image based on redeye pixel areas detected in the thumbnail image.

1 48. The method of claim 47, further comprising displaying the
2 thumbnail image with corrected redeye, and correcting redeye in the input image
3 based on redeye pixel areas detected in the thumbnail image in respond to a user
4 command.

1 49. A method of processing an input image having lines of pixels with
2 original color values, comprising:
3 detecting one or more redeye pixel areas corresponding to respective areas
4 in the input image;
5 classifying each pixel in the input image corresponding to the detected
6 redeye pixel areas as a redeye pixel or a non-redeye pixel on a line-by-line basis
7 without reference to pixels in adjacent lines; and
8 correcting the original color values of pixels in the input image classified as
9 redeye pixels.

1 50. The method of claim 49, wherein a pixel in a given line is classified
2 with reference to an adjacent, previously-classified pixel in the given line.

1 51. The method of claim 49, wherein correcting redeye comprises
2 identifying discrete redeye pixel areas separated from eyelid regions.

1 52. The method of claim 51, wherein identifying discrete redeye pixel
2 areas comprises comparing at least one redeye pixel area size dimension to a
3 threshold.

1 53. The method of claim 52, wherein a discrete redeye pixel area is
2 identified based at least in part on a prescribed fraction of a respective grayscale
3 iris area centered at a corresponding pixel area and having a size maximizing
4 grayscale contrast between the grayscale iris area and areas surrounding the
5 grayscale iris area.

1 54. The method of claim 51, wherein correcting redeye comprises
2 classifying pixels in each non-discrete redeye pixel area based on skin tone
3 coloration.

1 55. The method of claim 49, wherein correcting redeye comprises
2 classifying pixels in each redeye pixel area based on a redness threshold.

1 56. The method of claim 49, further comprising correcting original color
2 values of pixels classified as redeye pixels by desaturating original color values.

1 57. The method of claim 49, further comprising correcting original color
2 values of pixels classified as redeye pixels by darkening the original color values.

1 58. A system for processing an input image, comprising a redeye
2 detection module operable to:
3 sub-sample the input image to generate a thumbnail image; and
4 detect redeye pixel areas in the thumbnail image.

1 59. The system of claim 58, wherein the redeye detection module
2 computes measures of pixel redness in the thumbnail image and identifies a
3 preliminary set of candidate redeye pixel areas based on the computed pixel
4 redness measures.

1 60. The system of claim 59, wherein the redeye detection module
2 applies a two-dimensional redness filter to the computed pixel redness measures,
3 wherein the redness filter is operable to compute a redness score based on a
4 central kernel pixel area and a pixel area surrounding the kernel pixel area.

1 61. The system of claim 59, wherein the redeye detection module
2 enlarges a given candidate redeye pixel area having a dimension below a
3 threshold size to generate an enlarged pixel area.

1 62. The system of claim 59, wherein the redeye detection module filters
2 from the preliminary set each candidate redeye pixel area located in an area of the
3 digital image having a computed grayscale contrast relative to at least one
4 respective neighboring pixel area less than a prescribed grayscale contrast
5 threshold.

1 63. The system of claim 59, wherein the redeye detection module is
2 further operable to:

3 identify a pixel boundary of a pixel region surrounding a given candidate
4 redeye pixel area;

5 classify pixels within the pixel boundary as red pixels and non-red pixels
6 by applying a threshold to the computed pixel redness measures; and

7 filter the given candidate redeye pixel area from the preliminary set when a
8 set of contiguous red pixels extends from the given candidate redeye pixel area to
9 the pixel boundary.

1 64. The system of claim 59, wherein the redeye detection module filters
2 candidate redeye pixel areas from the preliminary set based on proportions of
3 detected skin tone pixels in regions respectively surrounding the candidate redeye
4 pixels areas.

1 65. The system of claim 59, wherein the redeye detection module pairs
2 candidate redeye pixel areas in the preliminary set and filters unpaired candidate
3 redeye pixels areas from the preliminary set.

1 66. The system of claim 58, wherein the redeye detection module
2 detects redeye pixel areas in the input image and generates a set of detected
3 redeye pixel areas by merging redeye pixel areas detected in the input image with
4 redeye pixel areas detected in the thumbnail image.

1 67. The system of claim 58, further comprising a redeye correction
2 module operable to correct redeye in the input image based on redeye pixel areas
3 detected in the thumbnail image.

1 68. A system for processing an input image having lines of pixels with
2 original color values, comprising:

3 a redeye detection module operable to detect one or more redeye pixel
4 areas corresponding to respective areas in the input image; and

5 a redeye correction module operable to classify each pixel in the input
6 image corresponding to the detected redeye pixel areas as a redeye pixel or a non-
7 redeye pixel on a line-by-line basis without reference to pixels in adjacent lines,
8 and to correct the original color values of pixels in the input image classified as
9 redeye pixels.